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(54) Improvements in and relating to respirators.

(57) The present invention relates to a pump module (14) for a powered air purifying respirator assembly including a facepiece (1) and a filter canister (32). The pump module (14) comprises a housing (15) having an air inlet (16) and an air outlet (17) and containing a fan (22) and motor (24). The pump module is designed to be mounted directly on an air purifying respirator facepiece (1) for powering the respirator, the module (14) being intended either to be interposed between the respirator facepiece (1) and a filter canister (32), which may otherwise be connected to the respirator, or to be connected to the inlet of the filter canister (32).

The fan (22) may be either an axial fan or a centrifugal fan, and the fan and motor may be arranged relative to the housing inlet (16) and outlet (17) so as to minimise the extent to which the module projects from the facepiece and/or so that the motor will at least in part counterbalance the weight of the filter canister (32) about the axis of the pump module housing outlet (17).

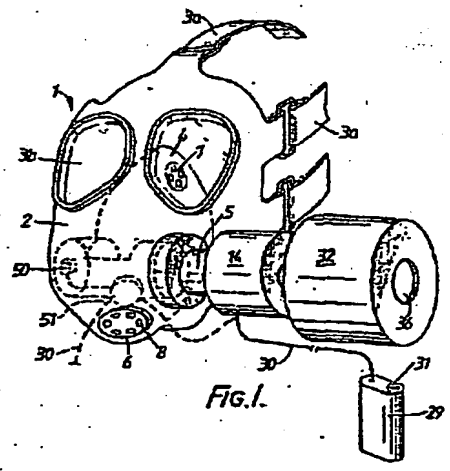

FIG.1.

EP 0 164 946 A2

Croydon Printing Company Ltd.

Improvements in and relating to respirators

The present invention relates to air purifying respirators of the type comprising a face mask covering the mouth and nose of the wearer and sealed to the wearer's head. Normally such masks include an inlet for air and an outlet provided with a one-way valve which opens to vent exhaled air within the mask. The mask inlet is adapted for connection to the outlet of a filter canister which is mounted on the mask for filtering air drawn into the mask by inhalation by the wearer. The filter material in the canister may be designed for removal of dust and/or vapour and/or gas from the ambient air.

Under some circumstances it can be advantageous to relieve the wearer of the effort required to draw air into the mask through the filter canister by providing a pump for positively drawing air through the filter and supplying it to the wearer. It has been proposed, for example in U.K. Specification No. 2032284 to provide such a pump within the outer housing of the facepiece. However such an arrangement has a disadvantage of requiring a specific design of the facepiece. Existing facepieces cannot be used.

According to one aspect of the present invention there is provided a pump module for releasable mounting on a respirator facepiece to be supported thereby and

comprising a housing having an inlet for air and an outlet adapted for communication with the inlet of the facepiece and, within the housing, a motor, and a fan connected to be driven by the motor and arranged with its inlet connected to the housing inlet and its outlet connected to the housing outlet.

According to another aspect of the present invention there is provided a powered air purifying respirator assembly comprising a facepiece for mounting on the head to cover the nose and mouth of the wearer and provided with an air inlet, an air outlet, and one-way valve means in the outlet permitting air to flow out of the facepiece, a filter canister for filtering air flowing into the air inlet of the facepiece and comprising a housing having an inlet and an outlet and, within the housing, filter material, and a pump module for pumping air to the facepiece and comprising a housing having an air inlet and an air outlet and, within the housing, a motor and a fan connected to be driven by the motor and arranged with the fan inlet connected to the housing inlet and the fan outlet connected to the housing outlet, the filter canister and pump module being adapted to be releasably mounted on the facepiece with the inlet of one of the housings connected directly to the outlet of the other housing and the outlet of the one housing connected to and engaged with the facepiece inlet.

The pump module may be adapted to be mounted directly on the facepiece with its housing outlet engaged with the inlet of the facepiece, the filter canister then being arranged with its housing outlet connected to the pump housing inlet. Alternatively, the pump module may be adapted to be mounted on the filter canister with its outlet communicating with the inlet of the filter canister, the outlet of the filter canister being engaged with the facepiece inlet.

The fan of the pump module may be an axial or centrifugal fan which is connected directly to the shaft of the motor which may be a d.c. motor driven by a battery. The batteries together with an on-off switch may be provided in a separate housing, for example to be located in a pocket in the wearer's clothing, and connected by wiring to the pump module.

To minimise the extent to which the pump module and filter canister project from the facepiece, with a filter canister which has co-axial inlet and outlet, the inlet and outlet of the pump module housing may be perpendicular or spaced apart but parallel, rather than co-axial. The former arrangement is advantageous where the pump module is arranged between the filter canister and the face mask and the latter is advantageous where the pump module is connected to the inlet of the filter canister, part of the housing of the pump module may then be laterally co-extensive with part of the housing of the filter canister.

Particularly where the pump module is connected to the inlet of the filter canister, the module may have a cheap construction because it is not necessary for it to be sealed against inadvertent ingress of atmospheric air. This can be particularly advantageous since, if the pump module becomes contaminated by the atmospheric dust/gas/vapour, it can be thrown away rather than decontaminated.

When the pump module is to be mounted on the filter canister inlet, its housing outlet may be provided with means for simple, releasable and quick engagement with and disengagement from the filter canister inlet and such that it can easily be attached to what may be a standard unpowered facepiece, when required by the user to assist the user's breathing.

The assembly of facepiece, pump module and

filter canister may be arranged to operate as described in published European Application No. 0094757 so that, during at least part of the exhalation cycle of the wearer, the pump is placed in a condition in which it ceases or substantially ceases to pump effectively, to prolong the life of the filter canister.

In addition, a pressure sensor may be provided in the region of the fan inlet for controlling power supply to the fan motor, as described in published U.K. Patent Application No. 2141348, to prolong the life of the filter canister and the motor batteries.

Alternatively, a pressure sensor may be provided within the facepiece and connected or connectable to the circuit for the fan motor for controlling power supply to the motor in dependence on the breathing cycle of the wearer, as described in U.K. Patent No. 2032284.

Embodiments according to the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an embodiment of a powered air purifying respirator assembly according to the present invention and comprising a facepiece, a filter canister and an embodiment of a pump module according to the present invention;

Figure 2 is a vertical section through the face mask of Figure 1;

Figure 3 is a vertical section through the filter canister and pump module of the embodiment of Figure 1;

Figures 4 and 5 are sections through embodiments of filter canisters and pump modules of other embodiments of powered air purifying respirator assemblies according to the present invention;

Figure 6 is a perspective view of another embodiment of a respirator assembly according to the

present invention and including another embodiment of pump module according to the present invention;

Figures 7 and 8 are sections through the filter canister and pump module of Figure 6;

Figure 9 is a perspective view of a further embodiment of a respirator assembly according to the present invention and including a further embodiment of pump module according to the present invention;

Figure 10 is a section on the line X-X of Figure 9; and

Figure 11 is a perspective view of another embodiment of facepiece.

The powered air purifying respirator assembly shown in Figures 1 to 3 comprises a conventional facepiece 1 which comprises an outer mask 2 for covering the face of the wearer and which is provided with straps 3a by which it is retained on the wearer's head. The outer mask 2 is intended to fit and seal peripherally against the wearer's face and is provided with viewing means, for example eye glasses 3b. Within the outer mask 2 there is an inner mask 4 which covers only the mouth and nose of the wearer and is held against the wearer's face by the outer mask 2.

The outer mask 2 is provided with an inlet 5 for air, the inner mask 4 has an outlet 6 and communication between the inner and outer masks is provided by one or more opening 7 in the inner mask.

The outlet opening 6 is provided with a one-way exhale valve 8 which opens against a bias e.g. provided by a compression spring so that it will only open when a predetermined relative positive pressure is attained within the face mask. The or each opening 7 may also be provided with a one-way valve 9 permitting air to flow from the outer mask into the inner mask but preventing exhaled air flowing into the outer mask. The inlet 5 may

also be provided with a one-way valve 10 permitting air to flow into the outer mask but preventing reverse flow.

As shown, the inlet 5 opens laterally of the face mask and on the left of the wearer. The outer mask may be provided with inlets both to the left and the right, only one of which is used in dependence on whether the user is left handed or right handed. Alternatively, the inlet may be provided centrally of the facepiece and directed forwardly (e.g. as shown in Figures 9 and 11). As shown, the inlet 5 has a radial flange 11 against which valve 10 seats and against which a sealing washer 12 is supported, and a threaded shroud 13.

As shown, a pump module 14 is connected directly to and supported on the facepiece. The pump module 14 comprises a cylindrical housing 15, for example moulded of plastics material, having coaxial inlet and outlet openings 16, 17. The outlet opening 17 has a threaded shroud 18 for threaded engagement with shroud 13 of the facepiece inlet, the end of which bears against washer 12 when the housing 15 is fully engaged with the facepiece. The inlet opening 16 has a configuration similar to opening 5 of the face mask with a radial flange 19, a sealing washer 20 and a threaded shroud 21.

Within the housing 15 there is an axial fan 22 which is connected directly to the shaft 23 of a d.c. motor 24. The motor is located in a casing 25 mounted by fins 26 on an intermediate casing 27 supported by resilient blocks 28 in housing 15. The fan 22 is arranged in the housing 15 with its inlet in communication with inlet 16 and its outlet in communication with outlet 17.

The motor 24 is powered by one or more batteries (not shown) which are housed separately in a housing 29, for example to be carried in a pocket of the wearer's clothing, and which is connected by a cable 30 to the motor 24. The circuitry within housing 29 may

include an on/off switch 31 for controlling power supplied to the motor 24.

A filter canister 32 is connected to the inlet opening 16 of the pump module. The filter canister may take any suitable form for filtering particulate material and/or gases and/or vapours. As shown, it is a conventional canister comprising a cylindrical housing 33 having an outlet 34 provided with a threaded shroud 35 for engagement in shroud 21 and an inlet 36. The canister is for filtering particulate material and gas and/or vapour and comprises a particulate material filter 37 across the inlet 36 and carbon granules 38 downstream of the filter 37.

Preferably the pump module 14 is provided with corresponding inlet and outlet configurations matching those of conventional facepieces and filter canisters, so that the pump module may be used as an optional addition to a conventional non-powered air purifying respirator, the pump module 15 being interposed between the facepiece and filter canister, when required, to assist the wearer's breathing.

Under some circumstances, it may be preferable not to have to interpose the pump module between the facepiece and the filter canister but simply to connect it to the filter canister inlet. Figure 4 shows an embodiment of pump module for use in this way. The facepiece, of which the inlet only is shown, is as described in relation to Figures 1 to 3, as is the filter canister. The same reference numerals will be used for like parts. So far as the pump module 14 is concerned, as in the preceding embodiment, it comprises a housing 15 and, within the housing 15, an axial fan 22 and motor 24. The mounting of the fan and motor within housing 15 is exactly the same as in the preceding embodiment. However in this embodiment, the inlet 16 of housing 15 is

a simple opening and the outlet 17 has an enlarged shroud 40 which is dimensioned to receive within it the inlet end portion of the cylindrical housing of the filter canister. The shroud 40 may be dimensioned to be a close fit on the inlet end of the canister housing and releasable engagement means, such for example as a resiliently flexible sleeve 41, may be provided on the shroud 40 for retaining the shroud relative to the filter canister housing. It will be appreciated that, from the point of view of the safety of the wearer, it is not essential to have sealed engagement between the pump module and the filter canister because the air received by the wearer will in any event be filtered by the filter canister. It is however preferable to have a reasonably sealed connection from the point of view of the efficiency of the pump module.

Advantageously the manner in which the pump module is engaged with the filter canister is designed to be simple and easy to achieve so that the pump module can be mounted on the inlet of a filter canister when the canister is in use attached to a facepiece.

To minimise the extent to which the assembly of filter canister and pump module project laterally from the facepiece, so as to minimise the moment of the weight of these components on the facepiece, it may be preferred to use a centrifugal fan rather than an axial fan. Figure 5 shows an embodiment of a pump module which has a centrifugal fan and is designed to be positioned between the facepiece and the filter canister. In this embodiment the pump module housing 14 has an inlet 16 and outlet 17, the axes of which are perpendicular. The configuration of the inlet 16 is exactly the same as in the embodiment of Figures 1 to 3 for receiving the outlet of a conventional filter canister. The outlet 17 has a shroud 18 which is received within the shroud 13 of the facepiece

inlet 5 and bears against the sealing washer 12. However, in this embodiment, because the final orientation of the pump module 14 relative to the facepiece is important for correct orientation of the inlet 16 and filter canister, the shroud 18 is not itself threaded but carries a threaded nut 45 which engages the thread of shroud 13. In this embodiment the motor 24 is simply mounted on an internal wall 46 of housing 15, shaft 23 extending between the motor 14 and the centrifugal fan 22 for communicating drive from the motor 24 to the fan 22. The inlet 22a of the fan 22 communicates directly with housing inlet 16 and its outlet communicates with outlet 17, the part of the housing surrounding the fan 22 being appropriately shaped to define the volute casing of the fan and the fan outlet.

It will be appreciated that the pump module 14 of this embodiment may be arranged with the axes of its inlet 16 and outlet 17 in either a generally horizontal plane (as shown) or in a vertical plane.

Figures 6, 7 and 8 show another embodiment of pump module using a centrifugal fan, the module being designed to be positioned at the inlet of the filter canister. In this embodiment the inlet 16 and outlet 17 of the housing 15 of the pump module have parallel but spaced axes so that the motor 24 can be arranged side-by-side with the filter canister 32. The fan 22 and motor 24 are mounted within housing 15 in the same way as in the embodiment of Figure 5 but, in this embodiment, the housing is provided with an internal wall 15a in part defining the volute casing of the fan and the fan outlet 22b, as shown in Figure 8, and is laterally extended to provide the outlet 17 which is, as in the embodiment of Figure 4, provided with a shroud 40 for engaging over the inlet end portion of the housing of the filter canister 32. The shroud 40 may be engaged with the filter canister

in exactly the same way as the shroud 40 of the embodiment of Figure 4.

In this embodiment, the pump module 14 is preferably arranged relative to the filter canister 32 with the motor 14 beneath the filter canister 32.

Figures 9 and 10 show yet another embodiment of pump module, somewhat similar to that of Figure 5, associated with a somewhat different design of facepiece 1. As in the previous embodiments, the facepiece 1 comprises an outer mask 2 for covering the face of the wearer and which is provided with straps 3a by which it is retained on the wearer's head. The outer mask 2 is provided with viewing means, which in this embodiment comprise a visor 3c. Within the outer mask 2 there is an inner mask 4 which covers only the mouth and nose of the wearer and is held against the wearer's face by the outer mask 2.

The outer mask is provided with a central forwardly directed inlet 5 for air which opens into the space between the inner and outer masks, and which may be provided with a one-way inlet valve (not shown). The inner mask 4 has an outlet 6 communicating with the interior of the inner mask, which opens forwardly and below the inlet 5 and which is provided with a one-way exhale valve (not shown) which opens against a bias to permit air to escape from the facepiece. As in the previously described facepiece, communication between the inner and outer masks is provided by one or more openings 7 in the inner mask, each of which may be provided with a one-way valve.

The pump module 14 is connected directly to the inlet 5 of the facepiece to be supported on and by the facepiece, and comprises a housing 15 having an air inlet 16 and an air outlet 17 which, as shown, is provided with a threaded shroud for threaded engagement with the inlet

5 of the facepiece. Within the housing 15 there is a centrifugal fan 22 and a motor 24 for driving the fan.

The housing 15 is conveniently made, e.g. moulded of plastics material, in three parts, comprising a generally planar internal wall or support member 46 which carries on one face the motor 24 and on the other the fan 22, the shaft 23 of the motor 24 projecting through wall part 46 to engage directly with the fan 22. Wall 46 has a peripheral flange 46a with which a generally cup-shaped housing part 15b surrounding the motor 24 is engaged. The third part 15c of the housing is also engaged with the flange and provides the volute casing of the fan 22 together with the housing axial inlet 16, the fan outlet and housing outlet 17.

The filter canister 32 is then connected to the inlet 16 of the pump module as in the embodiment of Figure 5.

A particular advantage of the above described pump module construction and its association with the facepiece and filter canister is that the moments of the mass of the motor and filter canister about the axis of the pump module outlet and facepiece inlet can be approximately balanced.

As so far described, the pump modules of all the above described embodiments operate continually so long as the on/off switch 31 is in its on position. However, a pressure sensor may be provided for controlling the power supplied to the motor and therefore the operation of the fan, as described in U.K. Patent No. 2032284. In accordance with U.K. Patent No. 2032284, a pressure sensor 50, shown in broken lines by way of example in Figure 1, may be provided within the outer mask. Since this pressure sensor 50 has to be connected in the circuitry of the motor 24, an electrical connector 51 may be provided on the facepiece for connection to the

batteries and on/off switch and to the motor 24 respectively.

Alternatively, the operating parameters of the pump module may be selected relative to those of the exhale valve 8 of the facepiece so that, as described in published European Patent Application No. 0094757, the pump will be placed in a condition in which it ceases or substantially ceases to operate effectively during part at least of the exhalation part of the breathing cycle of the wearer. In addition, in accordance with published U.K. patent application No. 2141348, and as shown in broken lines in the embodiments of Figures 3 and 5, a pressure sensor 52 may be provided for sensing the pressure in the region of the inlet of the fan and between the fan inlet and the filter canister. The pressure sensor may, as shown in Figure 3, be located in the region of the fan inlet, or, as shown in Figure 5, may be located elsewhere, e.g. in the part of the pump unit housing the motor which is then vented, and connected by ducting 53 to the region of the fan inlet.

It will be appreciated that, in all the above described embodiments, the pump module may be made very cheaply and its weight may be minimised by producing the majority of the components of plastics materials. It may thus be a "throw-away" item which is thrown away when it becomes contaminated or it ceases to operate effectively, rather than being cleaned and/or repaired for re-use.

It will also be appreciated that the above described pump modules may be used with other types of facepieces, for example with the facepiece 55 shown in Figure 11, which comprises a simple face mask designed to fit over the mouth and nose of the wearer and has an outlet 6 with an exhale valve located in the region of the nose of the wearer and an inlet 5 provided with a threaded shroud 13 centrally below the outlet and to which a

filter canister or pump module is connected to be supported on the facepiece.

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CLAIMS:

1. A pump module (14) for releasable mounting on a respirator facepiece to be supported thereby, comprising a housing (15) having an inlet (16) for air and an outlet (17) adapted for communication with the inlet of the facepiece, and, within the housing, a motor (24), and a fan (22) connected to be driven by the motor and arranged with its inlet connected to the housing inlet (16) and its outlet connected to the housing outlet (17).

2. A pump module as claimed in claim 1, wherein the housing outlet (17) is adapted for releasable engagement with the inlet of the facepiece, and the housing inlet (16) is adapted for releasable engagement with the outlet of a filter canister, the configerations of the housing outlet (17) and inlet (16) corresponding with each other such that the pump unit may be interposed between the inlet of the facepiece and the outlet of the filter canister which would otherwise be engageable together.

3. A pump module as claimed in claim 1, wherein the outlet (17) of the housing is adapted for releasable engagement with the housing of a filter canister for engagement with the inlet of the facepiece, so as to surround the inlet of the filter canister.

4. A pump module as claimed in claim 1 adapted for association with a filter canister having a generally cylindrical housing with an axial inlet and a coaxial outlet, the outlet being adapted for engagement with the inlet of the facepiece, wherein the outlet (17) of the pump module housing is provided with a shroud (40) for surrounding the housing of the filter canister adjacent the inlet thereof, and means (41) for releasably engaging

the pump module with the housing of the filter canister.

5. A pump module as claimed in any one of the preceding claims, wherein the fan (22) is an axial fan and the inlet (16) and outlet (17) of the housing are coaxial.

6. A pump module as claimed in claim 5, wherein the housing (15) is generally cylindrical and the inlet (16) and the outlet (17) are coaxial therewith.

7. A pump module as claimed in any one of claims 1 to 4, wherein the fan (22) is a centrifugal fan, the housing (15) provides the volute casing of the fan, the fan (22) is connected directly to the motor (24) to be driven thereby, and the motor (24) is provided on that side of the fan (22) opposite the fan inlet.

8. A pump module as claimed in claim 7, wherein the motor (24) and housing inlet (16) lie to either side of the axis of the housing outlet (17) so that the weight of the motor will, in use, at least in part counter-balance the weight of any means connected to the housing inlet (16).

9. A pump module as claimed in any one of claims 1 to 4, wherein the fan is a centrifugal fan, the inlet (16) of the housing is generally coaxial with the inlet of the fan, and the outlet (17) of the housing extends from but perpendicular to the outlet of the fan and is parallel to but spaced from the axis of the inlet (16) of the housing, the motor (24) being arranged below the outlet (17) of the housing and projecting from the plane of the outlet (17) of the housing so as in use to extend below means connected to the housing outlet (17).

10. A powered air purifying respirator assembly comprising a facepiece (1) for mounting on the head to cover the nose and mouth of the wearer and provided with an air inlet (5), an air outlet (6), and a one-way valve means (8) in the outlet permitting air to flow out of the facepiece, a filter canister (32) for filtering air flowing into the air inlet of the facepiece and comprising a housing (33) having an inlet (36) and an outlet (34) and, within the housing (33), filter material (37, 38), and a pump module (14) for pumping atmospheric air to the facepiece and comprising a housing (15) having an air inlet (16) and an air outlet (17) and, within the housing, a motor (24) and a fan (22) connected to be driven by the motor and arranged with the fan inlet connected to the housing inlet (16) and the fan outlet connected to the housing outlet (17), the filter canister (32) and pump module (14) being adapted to be releasably mounted on the facepiece with the inlet (16 or 36) of one of the housings (15 or 33) connected directly to the outlet (34 or 17) of the other housing (33 or 15) and the outlet (17 or 34) of the one housing (15 or 33) connected to and engaged with the facepiece inlet (5).

11. A respirator assembly as claimed in claim 10, wherein the outlet (17) of the pump module housing is connected to and engaged with the facepiece inlet (5).

12. A respirator assembly as claimed in claim 11, wherein the configurations of the outlet (17) and inlet (16) of the pump module housing correspond with each other such that the pump module (14) can be interposed between the inlet (5) of the facepiece and the outlet (34) of the filter canister (32) which are otherwise directly engageable together.

13. A respirator assembly as claimed in claim 10, wherein the outlet (34) of the housing (33) of the filter canister (32) is connected directly to and engaged with the facepiece inlet (5).

14. A respirator assembly as claimed in claim 13, wherein the outlet (17) of the housing (15) of the pump module (14) is adapted for releasable engagement with the housing (33) of the filter canister (32) surrounding the inlet (36) thereof.

15. A respirator assembly as claimed in claim 14, wherein the housing (33) of the filter canister (32) is generally cylindrical and the inlet (36) is coaxial therewith, and the outlet (17) of the pump module housing (15) is provided with a shroud (40) for surrounding the filter canister housing (33) adjacent the inlet thereof, and means (41) for releasably engaging the pump module housing outlet (17) with the filter canister housing (33).

16. A respirator assembly as claimed in any one of claims 10 to 15, wherein the fan (22) is an axial fan and the inlet (16) and outlet (17) of the pump module housing (15) are coaxial.

17. A respirator assembly as claimed in claim 16, wherein the pump module housing (15) is generally cylindrical and the inlet (16) and outlet (17) thereof are coaxial therewith.

18. A respirator assembly as claimed in any one of claims 10 to 15, wherein the fan (22) is a centrifugal fan, the inlet (16) and outlet (17) of the pump module housing are coaxial with the inlet and outlet of the fan, and the motor (24) for the fan is arranged on one side

of the fan opposite the fan inlet.

19. A respirator assembly as claimed in claim 18, wherein the outlet (17) of the pump module housing is connected directly to and engaged with the facepiece inlet (5), the filter canister (32) is connected to the inlet (16) of the pump module housing, and the weight of the motor at least in part counterbalances the weight of the filter canister (32) about the axis of the pump module outlet (17).

20. A respirator assembly as claimed in any one of claims 10 to 15, wherein the fan (22) is a centrifugal fan, the inlet (16) of the pump module housing being coaxial with the inlet of the fan, the outlet (17) of the pump module housing extending from the outlet of the fan perpendicularly thereto so as to be parallel to but spaced from the axis of the inlet (16), and the motor (24) is arranged to one side of the fan (22) opposite the side provided with the fan inlet so as to extend below the outlet (17) of the pump module housing.

21. A respirator assembly as claimed in claim 20, wherein the outlet (17) of the pump module housing is connected to the inlet (36) of the filter canister housing (33) and the motor (24) of the pump module extends below the filter canister (32).

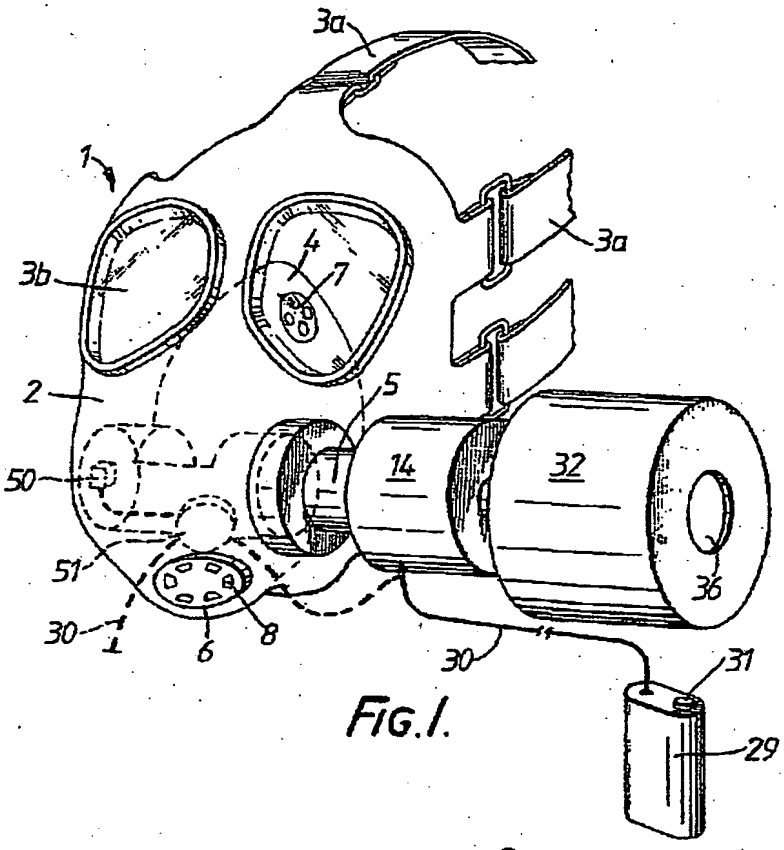
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FIG.1.

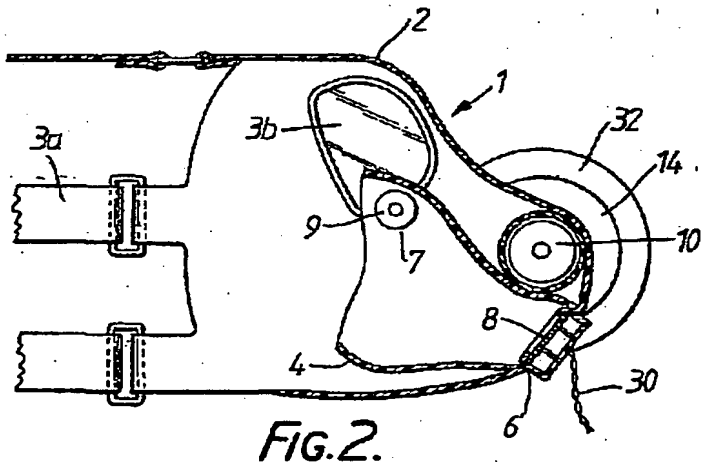
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FIG.2.

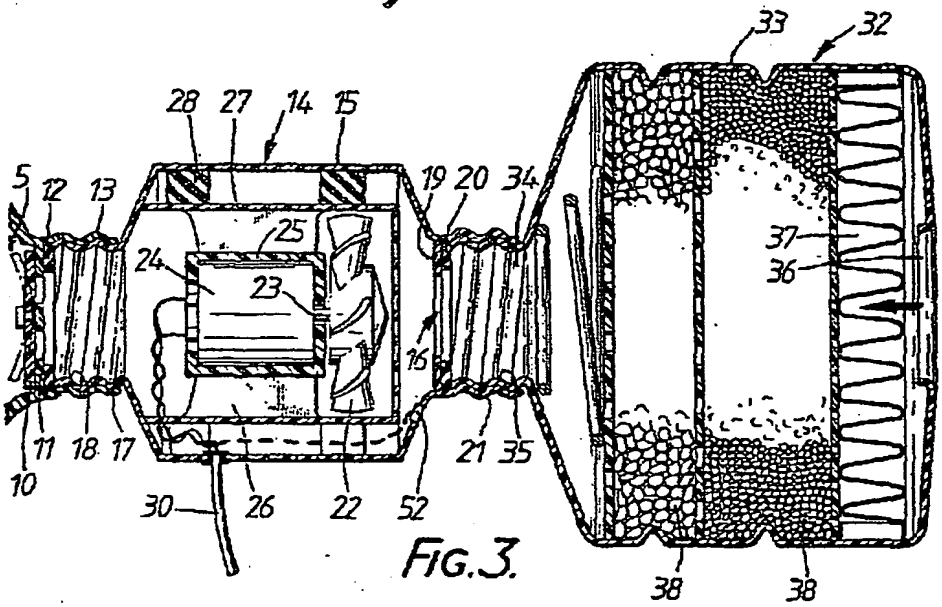
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FIG.3.

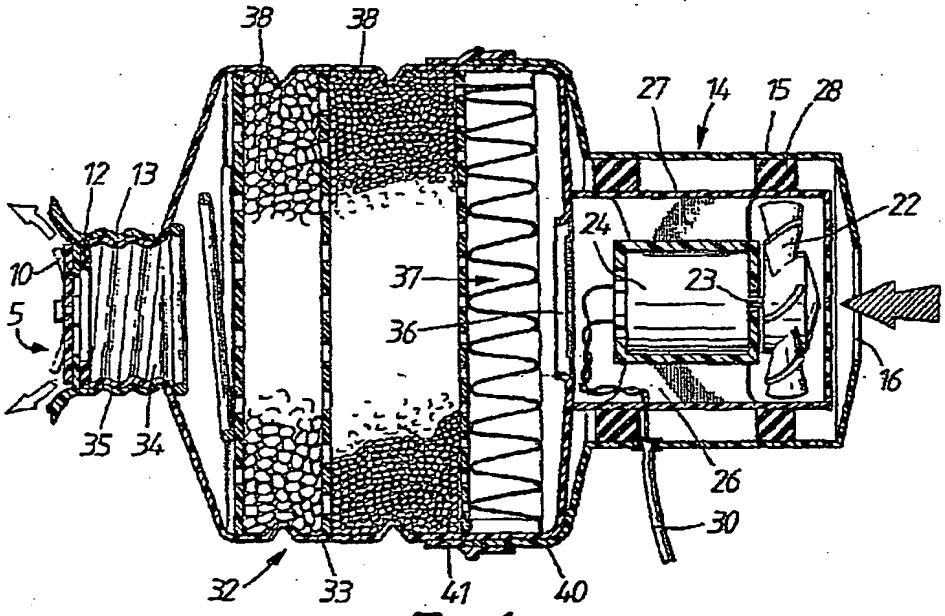
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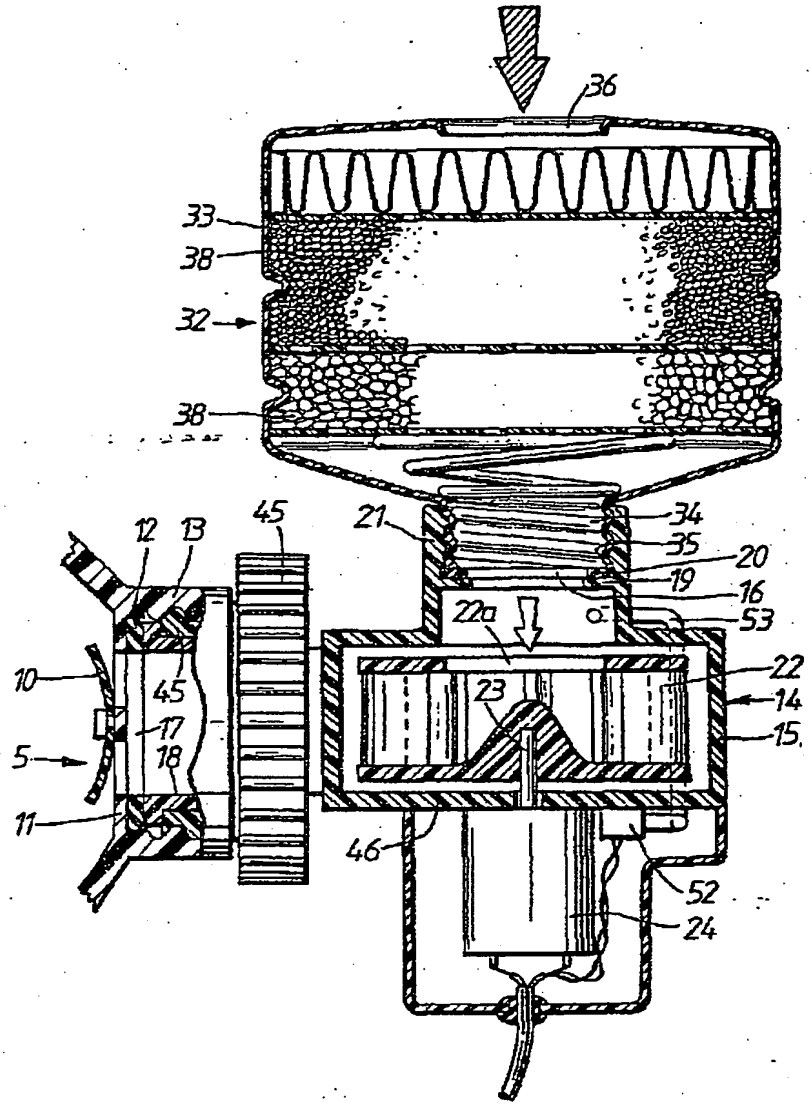
FIG.4.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13
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34
35
20
19
16
53
22a
22
23
14
15
10
45
17
18
5
11
46
52
24

FIG.5.

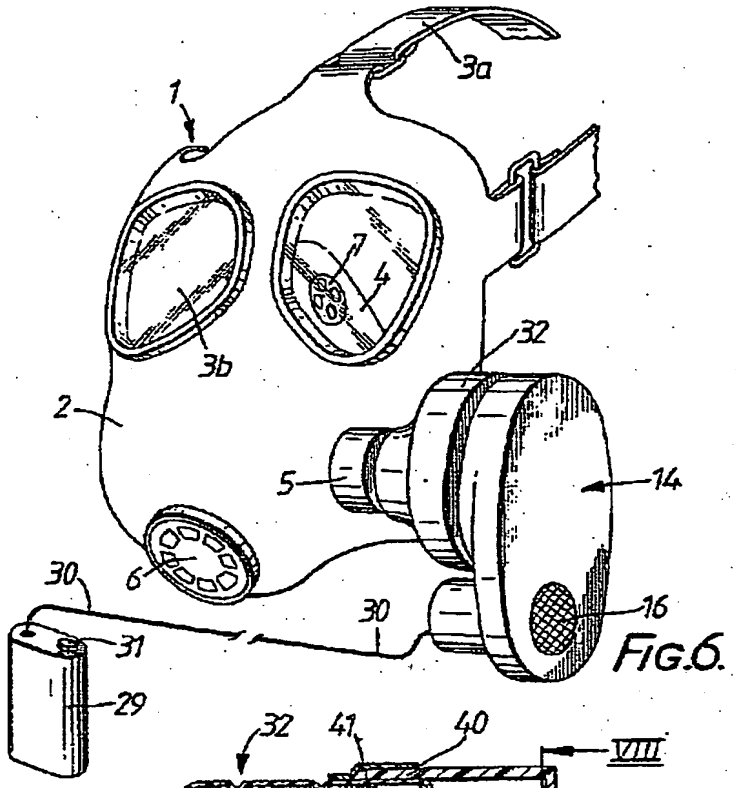
1
3a
3b
2
7
4
32
5
14
6
30
16
30
31
29

FIG.6.

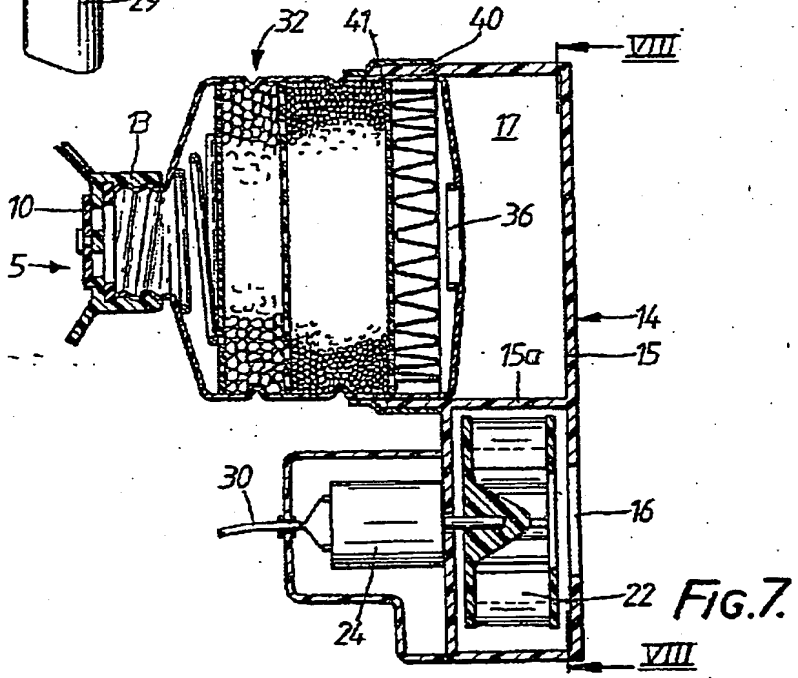
32
41
40
VIII
13
17
10
36
5
14
15a
15
30
16
22
24
VIII

FIG.7.

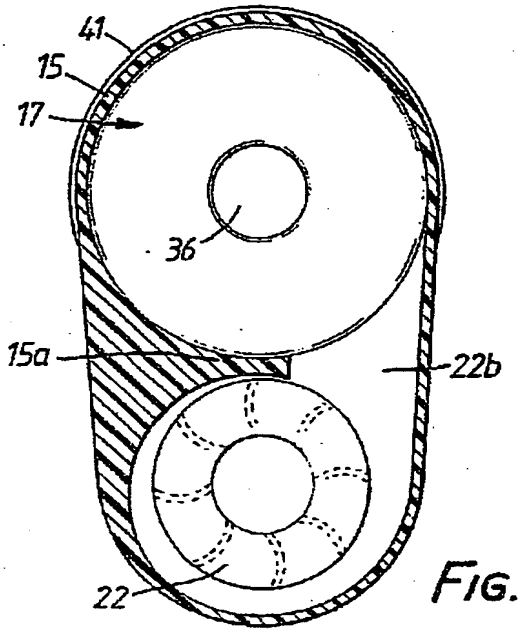

FIG.8.

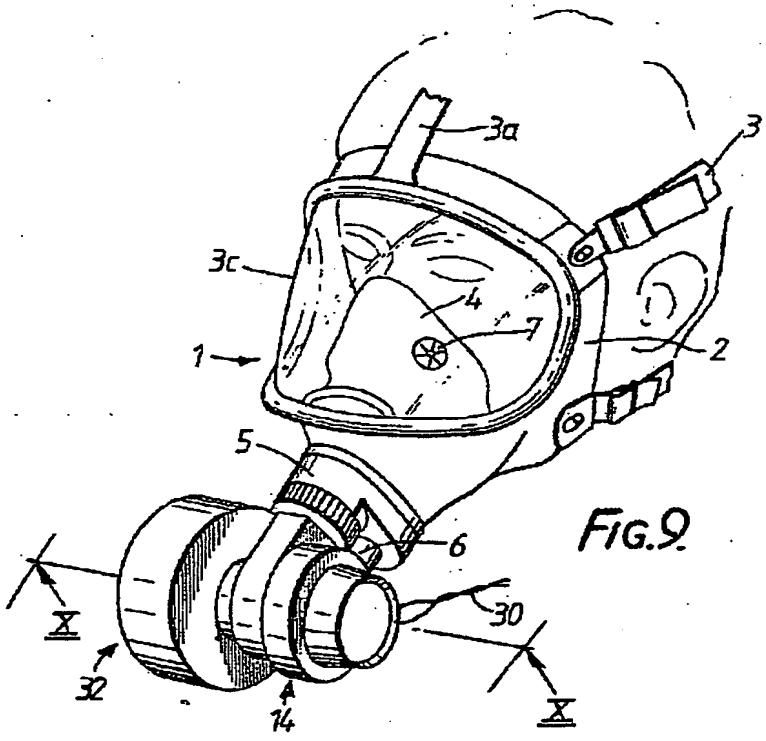

FIG.9

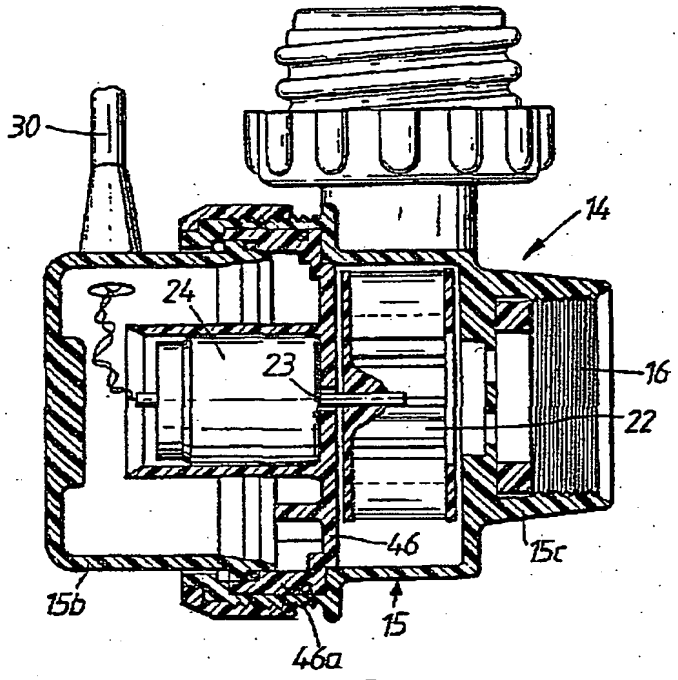

FIG.10.

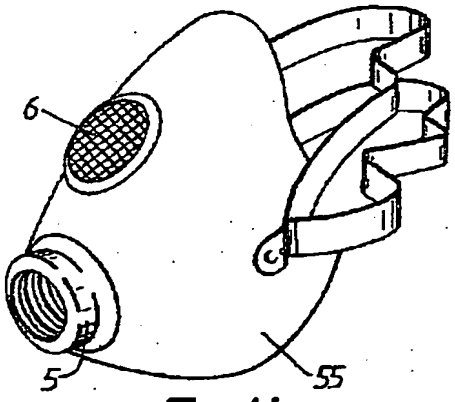

FIG.11.